CBCS SCHEME

USN | | | | | | | | | | |

BCHEE102/202

First/Second Semester B.E./B.Tech. Degree Examination, Dec.2024/Jan.2025

Chemistry for EEE Stream

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. VTU Formula Hand Book is permitted.
3. M : Marks , L: Bloom's level , C: Course outcomes.

		Module – 1	M	L	C
Q.1	a.	Explain the conductors, semiconductors and insulators based on band theory.	7	L2	CO1
	b.	Describe the purification of electronic grade Silicon by Float zone method.	6	L2	CO1
	c.	What are conducting polymers? Explain the mechanism of conduction in polyacetylene.	7	L2	CO1
		OR			
Q.2	a.	What is electrolessplating? Describe electroless plating of copper in the manufacture of double sided PCB.	6	L2	CO1
	b.	Explain the preparation, properties and commercial applications of graphene oxide.	7	L2	CO1
	c.	Define number average and weight average molecular weights. In a sample of a polymer, 20% molecules have molecular mass 15000 g/mol, 35% molecules have molecular 25000 g/mol and remaining molecules have molecular mass 20000 g/mol. Calculate the number average and weight average molecular weights of the polymer. Calculate PDI and comment on it.	7	L3	CO1
		Module – 2			
Q.3	a.	What are PV cells? Explain the construction and working of a typical PV cell. Mention its advantages.	6	L2	CO2
	b.	What are fuel cells? Describe the construction and working of methanol-oxygen fuel cell.	7	L2	CO2
	c.	Explain the construction and working of Lithium polymer battery. Mention its applications.	7	L2	CO2
		OR			
Q.4	a.	What are batteries? Describe the classification of battery with suitable examples.	6	L2	CO2
	b.	Explain the construction and working of Vanadium flow battery. Mention its applications.	7	L2	CO2

	c.	Explain the construction and working of sodium ion battery. Mention its applications.	7	L2	CO2
		Module – 3			
Q.5	a.	Define Corrosion. Describe electrochemical theory of corrosion taking iron as an example.	7	L2	CO3
	b.	What is anodisation? Explain anodisation of aluminium and mention its applications.	7	L2	CO3
	c.	Define corrosion penetration rate. A thick brass sheet of area 400 $inch^2$ is exposed to moist air. After 2 years of period, it was found to experience a weight loss of 375 g due to corrosion. If the density of brass is 8.73 $gram/cm^3$. Calculate CPR in mpy and mmpy units.	6	L3	CO3
		OR			
Q.6	a.	What is differential aeration corrosion? Describe differential aeration corrosion with suitable examples.	7	L2	CO3
	b.	Describe sacrificial anodic method of corrosion control with example.	6	L2	CO3
	c.	What is e-waste? Describe the ill effects of e-waste on environment and human health.	7	L2	CO3
		Module – 4			
Q.7	a.	Mention the properties and application of nano sensors and nano fibers.	6	L2	CO4
	b.	Describe the synthesis of nanomaterial by Sol-gel method. Mention its advantages and disadvantages.	7	L2	CO4
	c.	What are QLED's? Mention their properties and applications.	7	L2	CO4
		OR			
Q.8	a.	What are nano materials? Explain the following size dependent properties of nano materials: (i) Surface area (ii) Conducting property (iii) Catalytic property	7	L2	CO4
	b.	What are OLED's? Mention their properties and applications.	6	L2	CO4
	c.	What are perovskites materials? Give the properties and applications of perovskites materials in optoelectronic devices.	7	L2	CO4
		Module – 5			
Q.9	a.	What are concentration cells? The emf of a cell $Ag_{(s)}/AgNO_3(0.02M)//AgNO_3(xM)/Ag_{(s)}$ found to be 0.084 V at 298 K. Write the cell reactions and calculate the value of x.	6	L3	CO5
	b.	Describe the principle, instrumentation and application of potentiometric sensors for the estimation of Iron.	7	L3	CO5

	c.	What are reference electrodes? Explain the construction and working of Calomel electrode.	7	L2	CO5
		OR			
Q.10	a.	Describe the principle, instrumentation and application of conductometric sensors for the estimation of weak acid.	7	L3	CO5
	b.	What are ion selective electrodes? Explain the construction and working of glass electrode.	7	L2	CO5
	c.	Explain the principle and working of colorimetric sensors for the estimation of copper.	6	L3	CO5

*****

KLS VDIT - Haliyal
Dec - 2024 - Jan 2025
BCHEE102 / 202 QP solutions
Applied chemistry for EEE stream
Staff incharge: Dr. Sneha Kulkarni, Sem-1/2

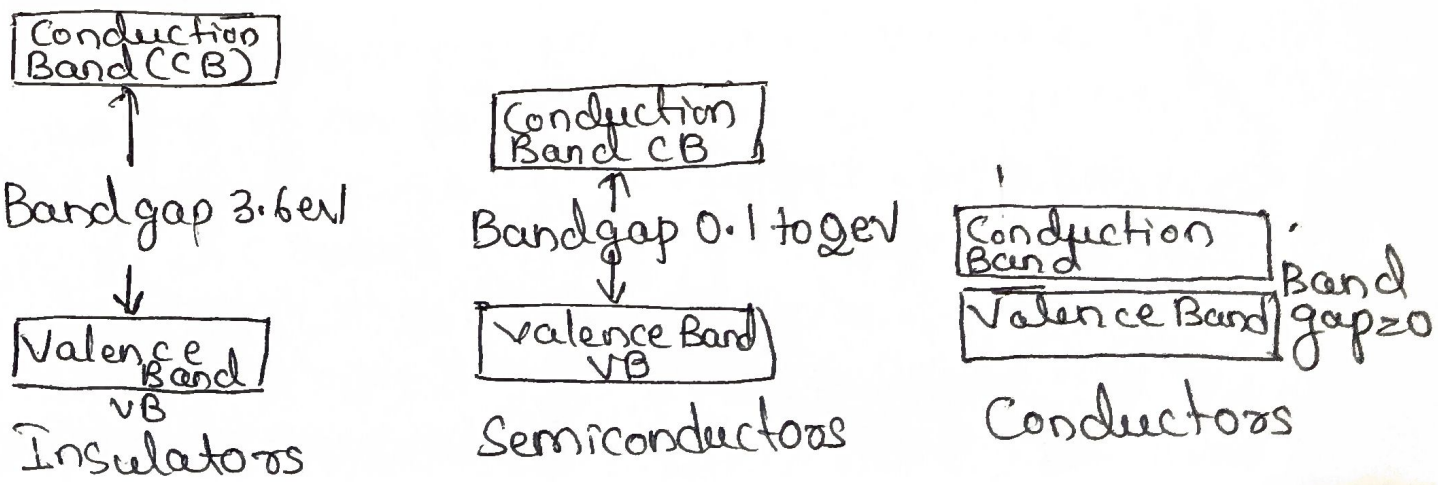
Module - 1

1a Explain the conductors, semiconductors and insulators based on band theory. TM

→ Conductors: These have overlapping valence and conduction bands or their valence band is partially filled. This overlap or partially filling allows electrons to move freely between energy levels and conduct electric current with little resistance Ex: Metals

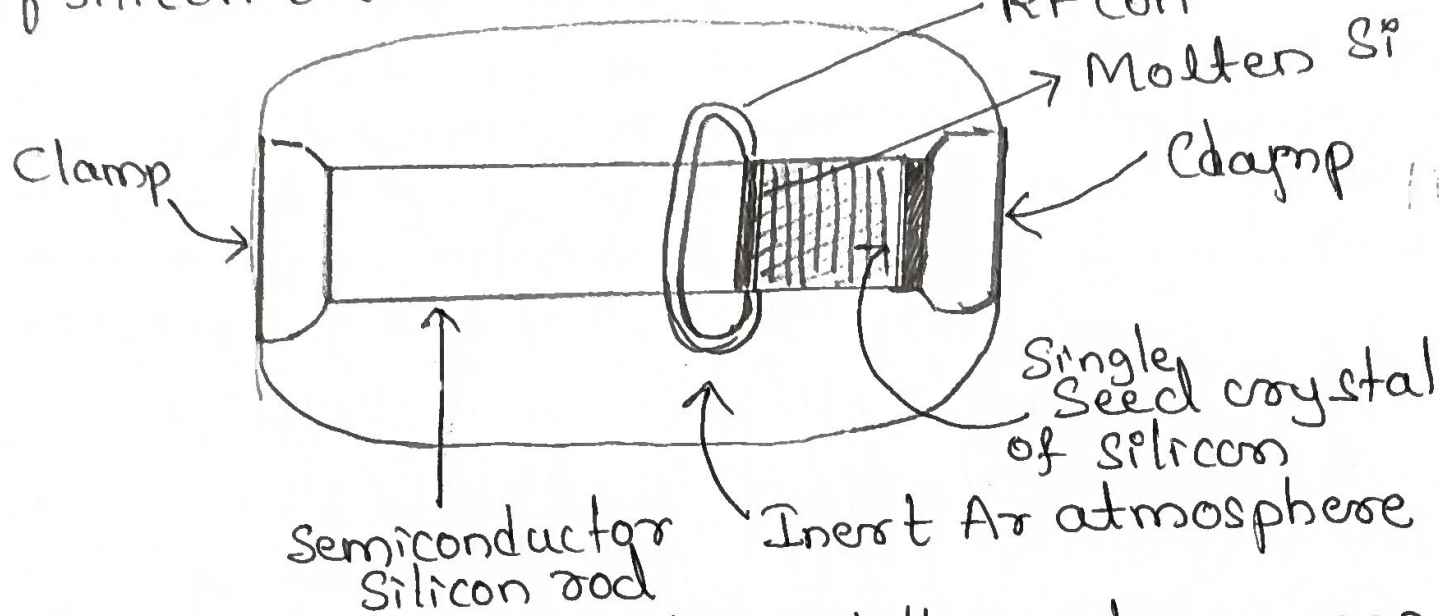
→ Insulators: These are having a relatively large bandgap, typically on the order of several electrons volts. The electrons in the valence band are typically tightly bound and the energy required for them to transition to the conduction band is too high As a result insulators do not conduct electrecity effectively. Ex: glass, wood

→ Semiconductors: Substances with conductivity in between conductor and insulator in the order 10^{-6} to 10^{2} ohm^{-1} km^{-1}. They have properties that can be manipulated to act as either conductors or insulators.. Ex: Si, Ge. They have smaller bandgap compared to insulators typically in the range 0.1 to 2eV.



1b Describe the purification of electronic grade Silicon by Folat zone method. 6M

→ Single crystal silicon can also be obtained by float zone method. A rod of polycrystalline Silicon is clamped with a seed crystal (single) of silicon attached at one end.



A small region of polycrystalline silicon near the single crystal silicon is heated using RF (radio frequency) coil to the melting point of silicon (1420°C). in an inert atmosphere say argon gas. As the RF coil is moved, the melt portion stasts solidifying with crystallographic orientation of seed crystal. RF coil is moved to the farthest end slowly. Because, the impurities will be more soluble in the silicon melt than in solid silicon, impurities will also move along with melt. Thus pure silicon solidifies behind the melt. The process is repeated number of times to get ultra pure silicon. When the process is complete, the portion where the impurities are concentrated is removed.

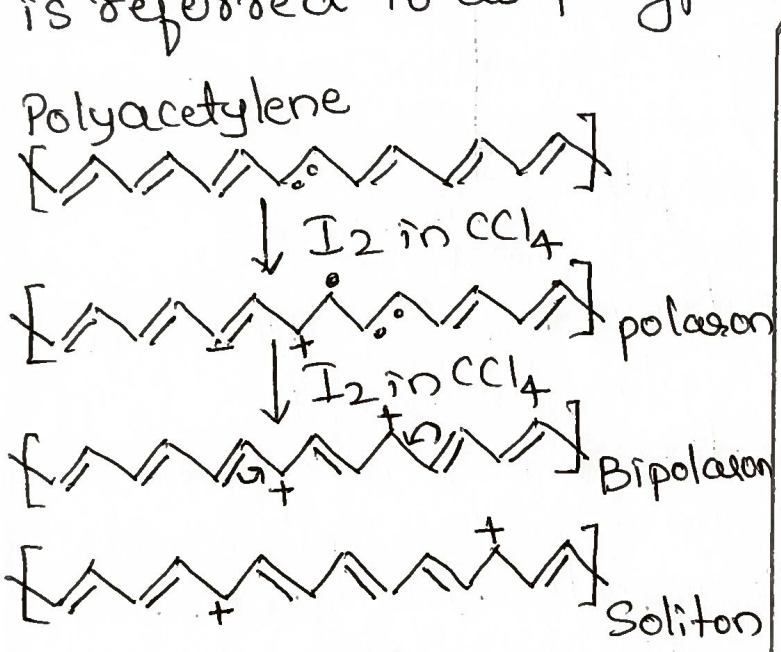
1c What are conducting polymers? Explain the mechanism of conduction in polyacetylene. 7M

Linear, organic polymers with conjugate single and double bonds with suitable doping by oxidation or reduction or proton etc. with delocalized π-electron system, exhibiting Conductivity equivalents of metals

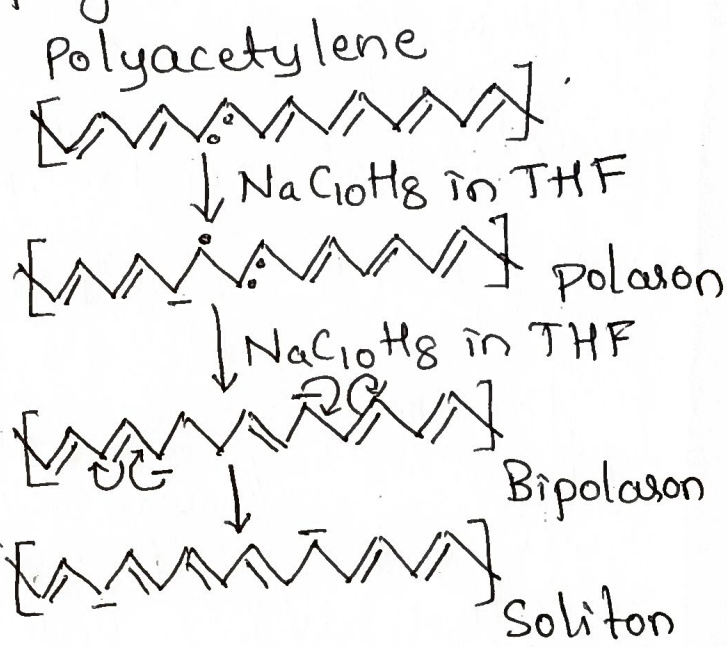
Mechanism of conductivity in polyacetylene

Non conducting trans polyacetylene on oxidative doping or reductive doping gives conducting polyacetylene.

→ Oxidative doping: In the 1st step, oxidative doping by I_2 in CCl_4 removes an electron from the conjugated chain forming radical cation or polaron Further oxidation gives bipolaron. Radicals converge and lead to formation of soliton. Delocalization of the positive charge imparts conductivity to the polymer. Thus, the oxidative doping of the polymer is referred to as p-type doping.



oxidative doping.



Reductive doping

Extensive doping or oxidation of the chain leads to higher conductivity to the polymer. Similaly, the reductive doping by dopant like sodium naphthalide in THF results in negative charge carriers in the polymer chain and is referred as - n type doping.

2a. What is electroplating? Describe electroless plating of copper in the manufacture of double sided PCB. 6M

Deposition of metal or alloy over a conducting or non conducting substrate surface by chemical reduction of metal ions by use of reducing agents. and without using electrical energy.

Making of double sided PCBs with through hole connections

→ A coating of copper on both sides of a glass reinforced plastic (GRP) sheet/board is accomplished by cladding two thin foils of copper.
→ Necessary circuits are drawn on either sides using etch-resistant ink.
→ The board is etched in acidified solution of $FeCl_3$ Only etch resistant circuit part are left and rest of the copper is etched away.
→ Holes are drilled, wherever contact between the two circuits is necessary.
→ Holes surfaces are activated by treatment with acidified $SnCl_2$ and then with acidified $PdCl_2$.
→ Electroless plating of copper is carried out in a suitable bath as mentioned above to establish the contact between the two circuits through holes.

2b Explain the preparation, properties and commercial applications of graphene oxide. 7M

Preparation

Graphite $\xrightarrow[+NaNO_3]{KMnO_4+H_2SO_4}$ Graphite oxide $\xrightarrow{\text{Exfoliation}}$ Graphene oxide

Oxidn

It is prepared by Hummers and Offeman method Here graphite is treated with an excess of potassium permangnate, sulfuric acid and a small amount of sodium nitrate. The reaction will be complete between 8-12 hrs. At the end of the reaction, excess of the $KMnO_4$ is removed with a diluted solution of H_2O_2.

Properties

→ The structure will contain hydroxyl, carbonyl, epoxide, carboxyl groups attached and there is no certain formula for geaphene oxide.
→ Graphene oxide is hydraulic due to the functional groups and can be dispersed in water or other polar solvents.

→ Carbon atoms with sp^2 and sp^3 hybridization is a feature of graphene structure. Thus conductivity or insulation can be tuned by regulated oxidation or reduction. It can be made as insulator, semiconductor or even a good conductor by controlling the oxidation or reduction.
→ Go exhibits optical nonlinearity dependent on the band gap.
→ Exhibits high specific surface area and used in desalination of water and for removing toxic heavy metals from effluent water.
→ It is biocompatiable and can be functionalised easily.

Applications

→ Due to adjustible electrical and optical properties GO is used for energy storage devices, transparent electrodes, photodetectors, light emitting devices
→ GO can be used for the large scale production of graphene
→ GO membranes are used for water purification
→ Functional groups and biocompatiability make it useful in sensors, biosensors, components for medical applications including implants
→ GO membranes can be used for separation of gaseous components by selective diffusion.

2c Define number average and weight average Molecular Weights. In a polymer sample 20% molecules have molecular mass 15000 g/mol; 35% molecules have 25000 g/mol and remaining molecules have molecular mass 20000 g/mol. Calculate number average and weight average Mwts of polymer. Calculate PDI and comment on it. 7M

$N_i = N_1 + N_2 + N_3 \Rightarrow 20+35+45 = 100$

$N_iM_i = N_1M_1 + N_2M_2 + N_3M_3$

$= 20(15000) + 35(25000) + 45(20000)$

$= 3\times10^5 + 875000 + 9\times10^5$

$= 300\times10^3 + 875\times10^3 + 900\times10^3$

$= 2075\times10^3$

$$N_i(M_i)^2 = N_1(M_1)^2 + N_2(M_2)^2 + N_3(M_3)^2$$
$$= 20(15000)^2 + 35(25000)^2 + 45(20000)^2$$
$$= 45\times10^8 + 21875\times10^6 + 18\times10^9$$
$$= 4500\times10^6 + 21875\times10^6 + 18000\times10^6$$
$$= 44375\times10^6$$

To calculate Number average Mwt ($\bar{M}_n$)

$$\bar{M}_n = \frac{\sum N_iM_i}{\sum N_i} = \frac{2075\times10^3}{100}$$
$$= 20750$$

To calculate Mass average Mwt ($\bar{M}_w$)

$$\bar{M}_w = \frac{\sum N_i(M_i)^2}{\sum N_iM_i} = \frac{44375\times10^6}{2075\times10^3}$$
$$= 21.385\times10^3$$
$$= 21385$$

$$PDI = \frac{\bar{M}_w}{\bar{M}_n} = \frac{21385}{20750} \Rightarrow 1.030 \quad PDI > 1$$

The polymer synthetic and it is polydisperse nature. And it is less homogeneous

Number average Molecular weight.

It is the mass obtained when the total mass of all the molecules of a sample is devided by the total number of molecules

Molec Mass average Molecular weight

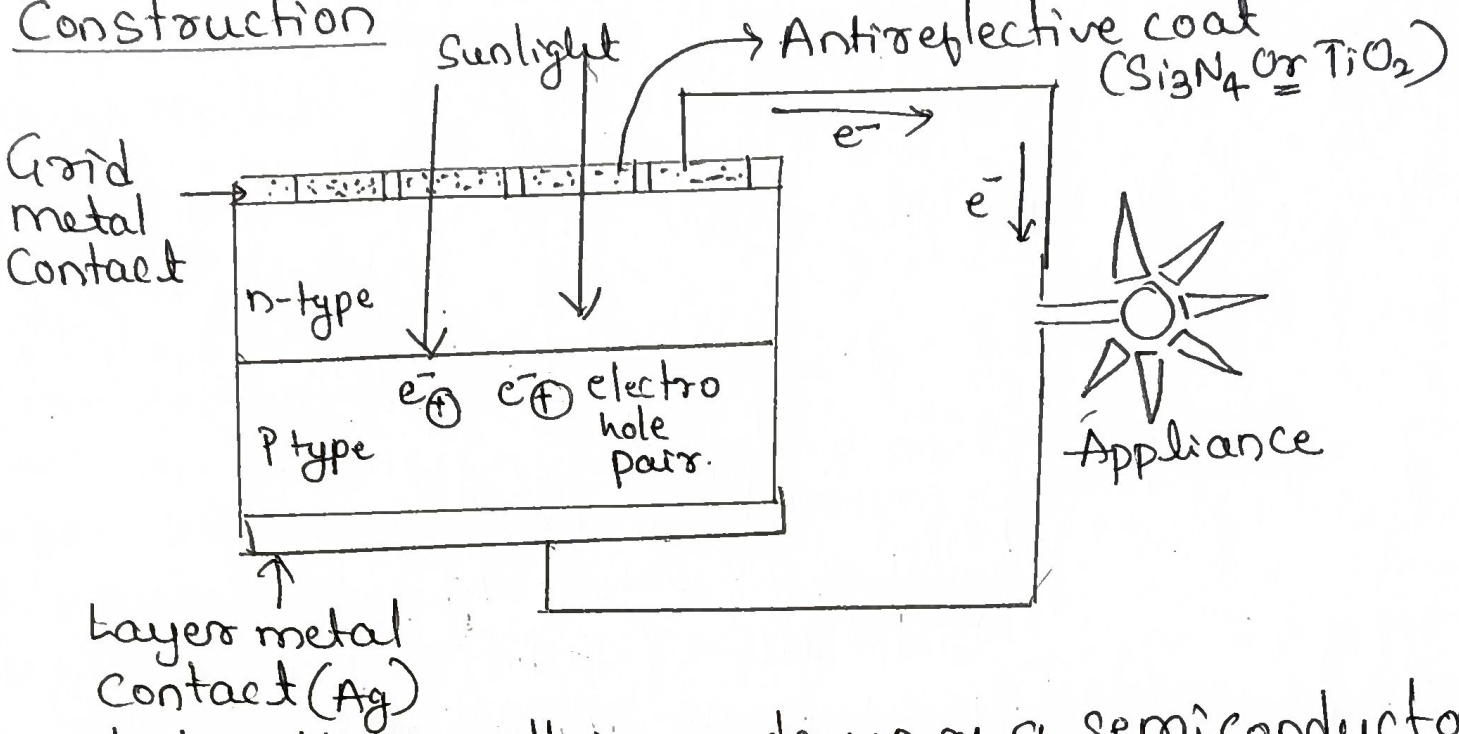
It is the mass obtained when sum of the products of total mass of groups of molecule and their respective molecular masses is devided by total weight of all molecules.

Module-2

3a What are PV cells? Explain the construction and working of a typical PV cell. Mention its applications. 6M

Photovoltaic cells or solar cells are devices that convert solar energy into electrical energy from semiconductors.

Construction



→ Photovoltaic cell is made up of a semiconductor diode

→ The diode has two electrical contacts. A grid metal contact is used on top side and a layer metal contact is used on the bottom side. Layer metal used is generally silver.

→ The metal grid permits the light to fall on diode between the grid lines.

→ An antireflective coat is used between the grid lines to increase the efficiency of light absorbance or energy conversion.

Working

→ When a electromagnetic radiation having energy enough to overcome the barrier potential falls normal to the surface of the p-n junction, electron hole pairs are formed

→ The electrons move towards the n region and holes move towards p-region

→ When an appliance or battery is connected between the two Contacts circuit is completed. and electrons are driven into external circuit enabling the functioning of appliance or charging of the battery Charged battery is used for application such as lighting, telecommunication etc.

3b What are fuel cells? Describe the construction and working of methanol-oxygen fuel cell 7M

Fuel cells are galvanic cells that ~~are~~ convert the chemical energy of a fuel-oxidant system directly into electrical energy by oxidation of fuel at anode and reduction of oxidant at cathode.

Methanol - O_2 Fuel cell

Porous C, CH_3OH H_2SO_4 | H_2SO_4 (aq) | O_2, porous C, (Pt) (Pt)

The cell consists of

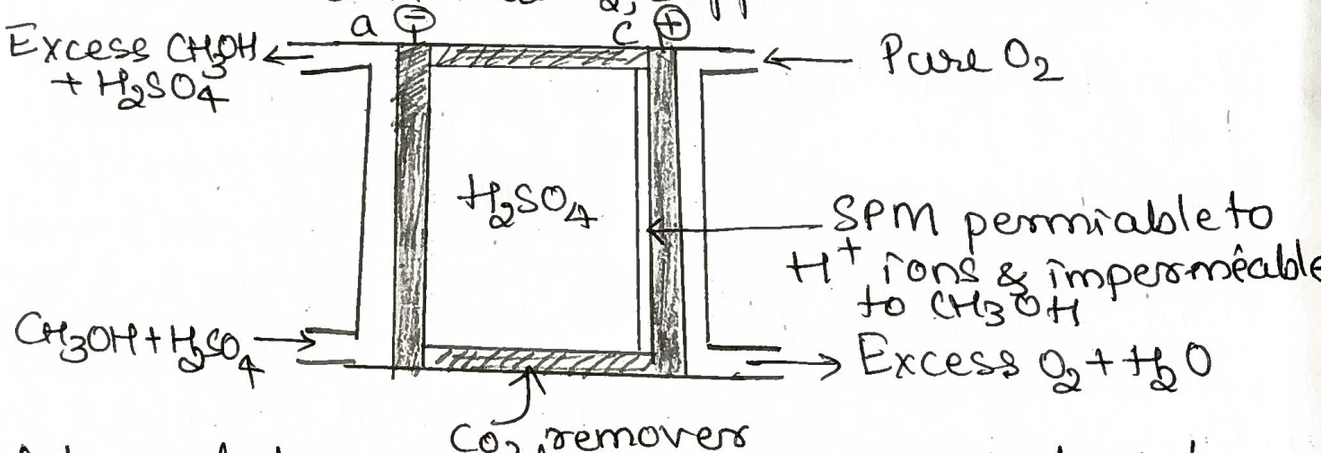
Anode: porous carbon dispersed with Pt

Cathode: Porous Carbon dispersed with Pt

Electrolyte: Aqueous H_2SO_4

Active components: Fuel: $CH_3OH + H_2SO_4$ supplied at anod

Oxidant: Pure O_2, supplied at cathode



Adjacent to cathode, towards the electrolyte side, a semi-permeable membrane is inserted to allow the diffusion of H^+ ions but disallow the defussion of methanol-oxidation directly at cathode.

→ Working:

Anodic oxidⁿ $CH_3OH + H_2O \longrightarrow CO_2 + 6H^+ + 6e^-$

Cathodic redⁿ $1\frac{1}{2}O_2 + 6H^+ + 6e^- \longrightarrow 3H_2O$

Cell reactⁿ $CH_3OH + 1\frac{1}{2}O_2 \longrightarrow CO_2 + 2H_2O$

water and CO_2 produced are removed as & when they are formed and do not harm the cell functioning. Water is removed by wicks.

Cell potential 1.2V

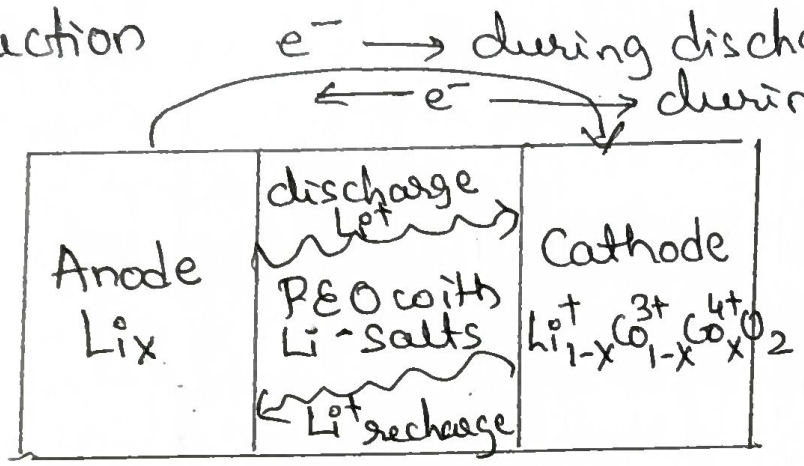
→ Application:

Used in military application and large scale power production

3c. Explain the construction and working of Lithium polymer battery. Mention its applications. 7M

Scheme: $Li \mid PEO$ composited with $Li^+ \mid LiCoO_2$

Construction



Anode: Li or Li in alloy

Cathode: $LiCoO_2$

Electrolyte: Polyethylene oxide with Li-salt dissolved in it, acts as Li^+ ion conductor but electronic insulator. PEO will act as separator between anode and cathode.

→ working:

Reactions in the forward direction occur during discharge of battery.

At anode $Li \rightleftharpoons Li^{o+} + e^-$

At cathode $CoO_2 + Li^{o+} + e^- \rightleftharpoons LiCoO_2$

$$Li + CoO_2 \rightleftharpoons LiCoO_2$$

Cell potential: 4.0V

Reactions are reversed during recharge

→ Applications: Batteries for cell phones & laptops etc

4a What are batteries? Describe the classification of battery with suitable example 6M

A battery is a union of two or more cells connected in series or parallel which serve as a source of energy.

Batteries are classified into 3 types

→ Primary battery:

Irreversible, to be discarded on discharge. Function as galvanic cell during discharge

Ex: $Zn-MnO_2$, $LiMnO_2$

→ Secondary battery: Reversible, are recharged after discharge from an external source of emf by reversal of polarity of the electrodes. Thus, they are rechargeable. The cells function as galvanic cell during discharge and electrolyte cell during recharge.

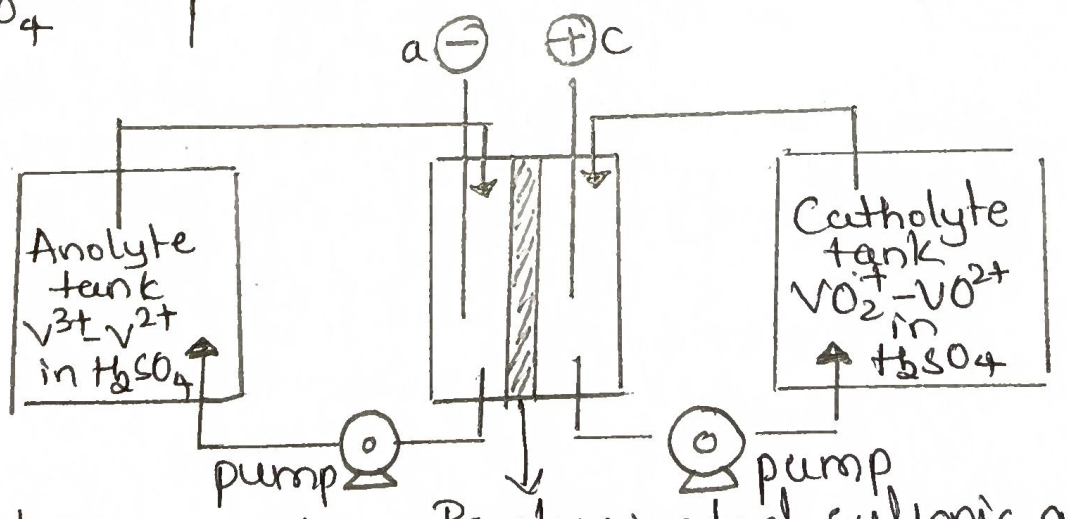
Ex: $Pb-H_2SO_4$, Li ion, $Ni-MH_2$, Ni-Cd etc

→ Reserve battery: Batteries with reserved activity with one of the essential battery component kept isolated. Batteries are activated by insertion of the isolated component during requirements of electric energy

Ex: $Pb|acid|PbO_2$, $Zn|KOH|Ag_2O$ etc

4b Explain the construction and working of vanadium flow battery. Mention its applications. -7M

Scheme: $V^{3+}-V^{2+}$ redox system dissolved in H_2SO_4	Proton exchange membrane perfluorinated sulfuric acid or Nafion	$VO_2^+-VO^{2+}$ redox system ($V^{5+}-V^{4+}$) dissolved in H_2SO_4



Perflourinated sulfonic acid

Discharge reactions

Anode: $V^{2+} \longrightarrow V^{3+} + e^-$

Cathode: $VO_2^+ + e^- + 2H^+ \longrightarrow VO^{2+} + H_2O$ ($V^{5+} \longrightarrow V^{4+}$)

$$V^{2+} + VO_2^+ + 2H^+ \longrightarrow V^{3+} + VO^{2+} + H_2O$$

cell potential: 1.15 to 1.55 V

Reactions are reversed during ~~discharge~~ recharge

Applications: Military equipment
UPS applications
Microgrids etc

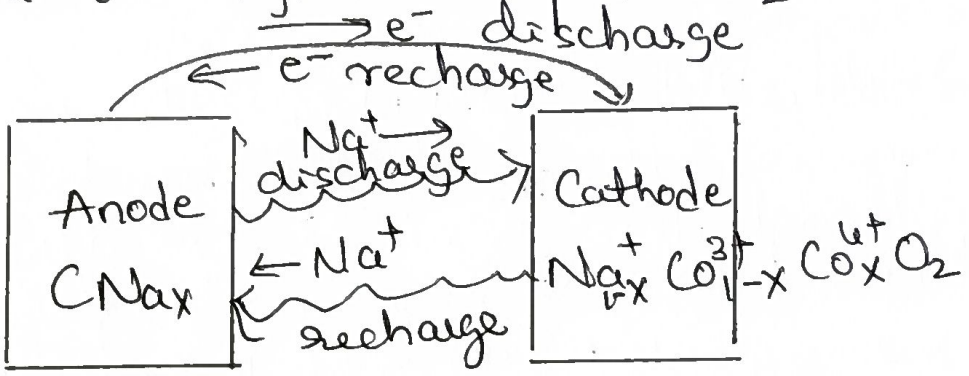
4c Explain the construction and working of ~~vanadium~~ sodium ion battery. Mention its applications. 7M

→ Scheme:

$Na_xC \mid$ Na-Salt in organic solvents $\mid Na^+_{1-x}Co^{3+}_{1-x}Co^{4+}_xO_2$

Actual construction

$Cu, C \mid NaPF_6$ in Org. Solvents $\mid NaCoO_2, Al$



→ Anode: Hard carbon

Cathode: Layered $NaCoO_2$

Electrolyte: $NaPF_6$ in organic solvents

Separator: Microporous polypropylene

This serves the purpose of an insulated separator between the electrodes and as electrolyte absorbent.

→ Working:

At Anode: $C\text{-}Na_x \rightleftharpoons C + xNa^+ + xe^-$

At cathode: $Na^+_{1-x}Co^{3+}_{1-x}Co^{4+}_xO_2 + xNa^+ + xe^- \rightleftharpoons NaCoO_2$

$$C\text{-}Na_x + Na^+_{1-x}Co^{3+}_{1-x}Co^{4+}_xO_2 \rightleftharpoons C + NaCoO_2$$

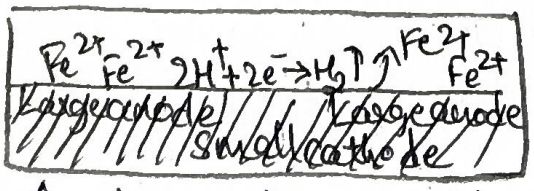
Applications: large scale grid storage

storage of renewable energy.

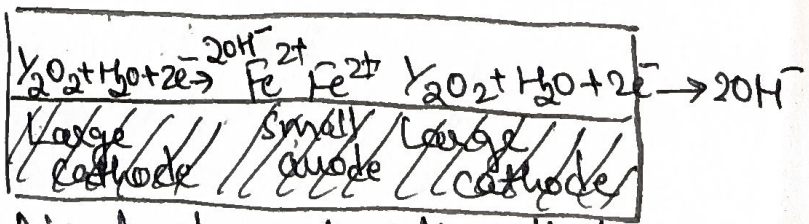
Module-3

5a. Define Corrosion. Describe electrochemical theory of corrossion taking iron as an example. 7M

→ Destruction or disintegration of metals when exposed to surrounding corrosive starting at their surface either by chemical or electrochemical means is called metallic corrosion.



Anodic acidic corrosive



Neutral or sligidly alkaline

Electrochemical theory of corrosion by taking steel as an example

This corrosion is characterized by the formation of small galvanic cells due to heterogenities. Part of metal acts as anode and another part act as cathode

→ Anodic part of the metal undergoes destruction by oxidation. Steel (Iron) undergoes corrosion by following reactions.

Anodic oxidⁿ $Fe \longrightarrow Fe^{2+} + 2e^-$

Reduction reaction depends on the contents in the medium. Some important reactions are—

→ H_2 Evolution type

$2H^+ + 2e^- \longrightarrow H_2$ [when the medium is acidic]

$2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$ [when the medium is neutral or slightly alkaline]

It is characterized by presence of large anode and small cathode area. Corrosion is uniform & less aggressive, higher the acidity, higher is the corrosion rate.

→ O_2 absorption type:

$\frac{1}{2}O_2 + H_2O + 2e^- \longrightarrow 2OH^-$ [when the medium is neutral or slightly alkaline]

$\frac{1}{2}O_2 + 2H^+ + 2e^- \longrightarrow H_2O$ [when the medium is acidic & presence of dissolved O_2]

Oxygen absorption is characterized by the presence of small anodic area & large cathode area. Corrosion is localized and very aggressive Higher the O_2 contained in the medium, higher is the corrosion rate.

Ferrous hydroxide is formed as corrosion product. Excess O_2 can oxidize it further to yellow and black rust.

$Fe^{2+} + 2OH^- \longrightarrow Fe(OH)_2 \downarrow$

$2Fe(OH)_2 + H_2O + \frac{1}{2}O_2 \longrightarrow Fe(OH)_3$
Yellow rust

$3Fe(OH)_2 + \frac{1}{2}O_2 \longrightarrow Fe_3O_4 \cdot 3H_2O$
magnetite or black rust

5b What is anodization? Explain anodization of aluminium and mention its applications. 7-M

Anodizing refers to chemical conversion coating over metal surfaces and control of corrosion. The method is applicable to nonferrous metals.

Anodizing of aluminium.

→ Aluminium article is made an anode in an electrolytic bath containing oxidizing agents such as chromic acid, H_2SO_4, oxalic acid etc

→ Cathode is made of lead or stainless steel

→ Moderate current density and temp are maintained to have better barrier between metal & medium.

→ There is formation of aluminium oxide coating over aluminium article, which grows in thickness with time.

$$2Al + 3[O] \longrightarrow Al_2O_3$$

→ Outer, porous oxide film is sealed by immersion into boiling water or metal salt solution. There is hydration of Al_2O_3 into $Al_2O_3 \cdot H_2O$ which will have expanded size & thus seals the pores.

Applications:

Used for many design or architectural purposes Used for making window frames & soap boxes.

5c Define corrosion penetration rate? A thick sheet of brass of area 400 $inch^2$ is exposed to moist air After two years of period, it was found to experience a weight loss of 375g due to corrosion. If the density of brass is 8.73 g/cm^3, calculate CPR in mpy and mmpy. 6M

To calculate CPR in mpy and mmpy the formula used is $CPR = \frac{KW}{DAT}$

CPR is the speed at which the metal or metal alloy undergoes corrosion or deterioration at specific corrosive environment at specific time.

CPR in mpy

$$CPR = \frac{KW}{DAT}$$

$$= \frac{534 \times 375 \times 10^3}{400 \times 2 \times 365 \times 24 \times 8.73}$$

$$= 3.27 \text{ mpy}$$

$K = 534$
$D = 8.73 \text{ g/cm}^3$
$W = 375\text{g} = 375 \times 10^3 \text{ mg}$
$A = 400 \text{ inch}^2$
$T = 2 \text{ years}$
$= 2 \times 365 \times 24 \text{ hrs}$

CPR in mmpy

$$CPR = \frac{KW}{DAT}$$

$$= \frac{87.6 \times 375 \times 10^3}{8.73 \times 400 \times 2 \times 6.145 \times 365 \times 24}$$

$$= \frac{32850000}{394609968}$$

$$= 0.832 \text{ mmpy}.$$

$K = 87.6$
$D = 8.73 \text{ g/cm}^3$
$W = 375\text{g} = 375 \times 10^3 \text{ mg}$
$A = 400 \text{ inch}^2$
$= 400 \times 6.145 \text{ cm}^2$
$T = 2 \text{ years}$
$= 2 \times 365 \times 24 \text{ hrs}.$

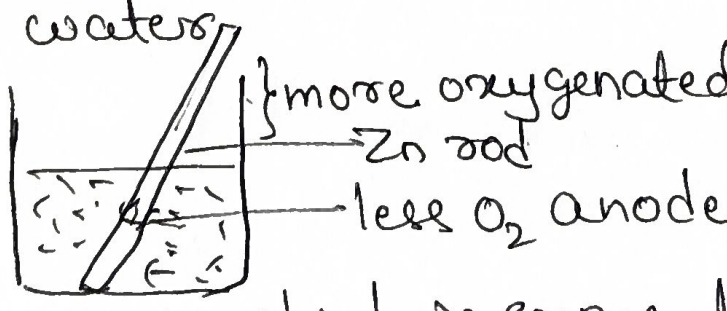
6a What is differential aeration corrosion? Describ differential aeration corrossion with example 7M

Corrosion arising out of difference in aeration of metal parts is called as differential aeration corrosion.

Part of metal exposed to less O_2 area acts as anode & undergoes corrosion. The part of metal exposed to more O_2 water area acts as cathode and undergoes reduction. Driving force for the corrosion is the difference in O_2 concentration at two different metal parts.

Ex: partially immersed metal in a solution water droplets over a metal sheet.

Suppose a zinc rod immersed partially in water



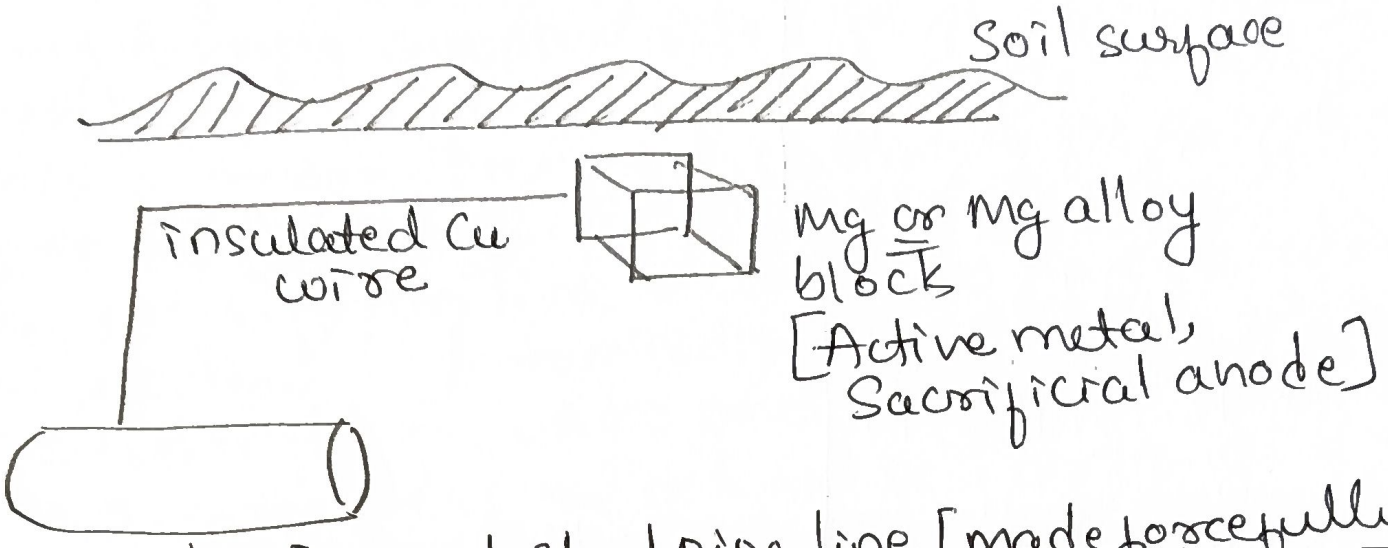
The zinc which is exposed to less O_2 undergoes corrosion $Zn \longrightarrow Zn^{2+} + 2e^-$

Cathodic redn $\frac{1}{2}O_2 + H_2O + 2e^- \longrightarrow 2OH^-$

Corrosion product $Zn + \frac{1}{2}O_2 + H_2O \longrightarrow Zn^{2+} + 2OH^-$

6b Describe sacrificial anodic method of corrosion with example. 6M

→ It is called as cathodic protection method.



→ object metal is connected to a active metal or metal alloy block.

→ whenever there is demand by the corrosives in the medium, anodic metal will sacrificially undergo oxidation and release electrons. Thus the object metal is protected.

→ As long as anodic metal block is active, protection is achieved. When it disappears, fresh block is replaced.

Applications:

→ Employed for buried pipe lines used for water or oil, water tanks, ocean going ships etc.

6c. What is E-waste? Describe the ill effects ewaste on environment and human health? 7M

Electronic waste is a term for electronic products that have become unwanted, nonworking or obsolete and have essentially reached the end of their useful life.

Ill effects

→ Informal e-waste recycling techniques employed for metal recovery from PCBs. Although the recycling is responsible to remove or delay the release of contaminants into the environment, unscientific ways are used

for reaycling may result in accumulation in landfills and endup within the environment.

→ Unscientific dumping of E-waste. The effluent from E-waste dumping sites is rich in heavy metals and suspended particulate matters. It is a major transport pathway for contamination of aquatic systems.

→ The use of primitive methods to process ewaste has resulted in contamination of soil. Many of the effluents are acidic and responsible for changing the pH of the natural soil and reduction of agricultural yields. Concentration of Pb, Ba, Cd Hg, Cr and Zn is found to be too much higher near dumping sites. Toxic elements are found to disturb the N and K absorption by plants which are important components in plants growth & development. Many of these heavy metals are carcinogenic. Toxic substances gradually enter ecosystem through crops.

→ Open burning of PCBs and electric cables to recover Cu. This releases toxins persistent organic pollutants, polyaromatic hydrocarbons PCBs, halogens and halogenated organics into the environment.

→ Cd-metal can damage kidneys and Pb-metal can have a direct influence toward central nervous system as well as deterioration of intelligence quotient in children. Hg is a potential mutagenic compounds and affects neutons.

→ Placentas collected from mothers who live near E-waste dumping sites have shown very high concentration of toxic chemicals.

→ Toxic substances are entering human body from air, water, and soil through inhalation, injestion and dermacontact. They are having bad effects on health.

7a. Mention the properties and applications of nano sensors and nano fibers. 6M

Nano sensors.

Properties

→ High sensitivity: They can detect even tiny concentrations of analytes due to the increased surface area and potential for enhanced interactions between the sensing materials and the target.

→ Fast response rate: The small size of nanosensors allows for rapid diffusion of molecules resulting in quicker response times compared to larger scale sensors.

→ Selectivity: Nanosensors can be engineered to exhibit high selectivity for specific analytes reducing interference from other substances.

→ Versatility: Nano sensors can be tailored for a wide range of applications by modifying the sensing in quicker response times compared to large scale sensors.

Applications.

→ Nanosensors contribute to vehicle safety by monitoring tire pressure, exhaust emissions and driver health.

→ Nano sensors can detect pollutants, toxins and gases in the environment, contributing to air and water quality monitoring and ensuring workplace safety.

→ Nano sensors are employed in energy systems to monitor temp, pressure and corrosion, improving efficiency and safety.

Nano fiber

Properties

→ High surface area: Nanofibers have a high surface area to relative to their volume, making them suitable for applications that involve adsorption, filteration, and interaction with other materials.

→ Tunable properties: By controlling factors like composition, structure and alignment nanofibers properties can be tailored for specific applications

→ Mechanical strength: Despite their small size
→ nanofibers can exhibit exceptional mechanical strength, making them suitable for reinforcement in composites and other materials.

Applications

→ Tissue Engineering
→ Drug delivery
→ Filteration and separation
→ Environmetal applications
→ Energy harvesting & storage
→ Electronics and sensors
→ Catalysts & catalysis
→ Optics and photonics.
→ Textiles
→ Pessonal care products

7b Describe the synthesis of nanomaterials by sol gel method. Mention its advantages and disadvantages. 7M

Sol-gel process: principle is conversion of precursor solution into gel via hydrolysis and condensation reactions.

It involves following steps.

1) Preparation of sol: Sol is prepared by suspended particles in water, during suspension hydrolysis reaction takes place.

$MOR + H_2O \longrightarrow MOH + ROH$.

2) Conversion of sol into gel: Sol is converted to gel by condensation reaction forming network between oxides. When networking takes place, viscosity of the solution increases.

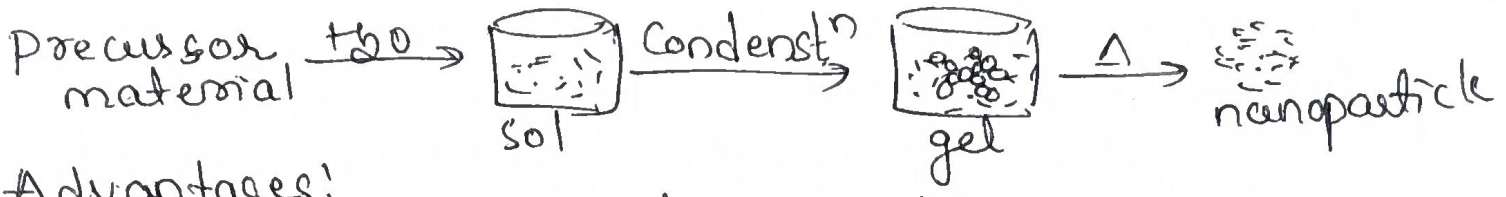
$MOH + MOH \longrightarrow MOM + H_2O$ [water condensation]

$MOR + MOH \longrightarrow MOM + ROH$ [alcohol condensation]

3) Aging of gel: during which poly condensation reaction continue until the gel is transformed into solid mass.

4) Removal of solvent: Further the solid mass is isolated from the solvent by thermal evapouration The product formed is xerogel

5) Heat treatment: Solid mass is dried nearly 800°C to get fine nano particle powder.



Advantages:
→ Samples can be prepared at low temp
→ Nanomaterials of high purity with good homogeneity can be obtained.

Disadvantages:
→ high precursor cost
→ Shrinkage and cracking during drying
→ It can also be a lengthy process.

7c. What are QLED's? Mention their properties & applications 7M

Properties:
→ high brightness
→ high efficiency with long lifetime
→ More flexibility
→ high quality light with superior color gamut
→ high colour rendering index
→ low processing cost
→ high quantum yields.
→ high molar extinction coefficients.
→ large effective stokes shift.

Applications:
→ displays are commonly used in televisions, monitors smartphones and other electronic devices.
→ Can also be used as a source of lighting in various applications. including automotive lighting, street lighting and architectural lighting.
→ Can be used in medical imaging applications such as MRI machines, to produce high resolution and accurate images.

QLEDs is display technology that uses a layer of quantum dots to enhance color and brightness in LED TVs.

8a. What are nanomaterials? Explain the following size dependent properties of nanomaterials. 7M

The nanomaterials are one which are having at least one dimension in the range 1-100nm

1) Surface area:

When we reduce the size of the

material (bulk) to nanosize the surface area to volume ratio increases. Properties like catalytic activity, gas adsorption and chemical reactivity depends on surface area, therefore nanomaterials show specific surface related properties that are not observed in bulk materials.

Ex: Bulk gold is catalytically inactive but the gold nanoparticles are catalytically active for selective redox reactions.

→ Catalytic properties.

If the size of the particles reduces from bulk to nanoscale, surface area increases, that leads to very high catalytic activity of the same material.

Bulk gold is catalytically inactive but gold nano particles are catalytically active.

→ Conducting / Electrical properties:

The electrical bands in bulk are continuous due to overlapping of orbitals of billions of atoms. But, in nanoparticles, very few atoms or molecules are present so the electric bands become separate and the separation between different electric state varies with the size of the material.

Hence some metals which are good conductors in bulk become semiconductor or insulators as their size in decreased to nanolevels

Ex: Silicon nanoparticles.

8b What are OLEDs? Mention their properties and applications

OLEDs are type of light emitting diode that utilize organic materials to emit light when an electric current is applied. 6M

Properties:

→ Thin and flexible
→ high contrast ratio and wide viewing angle
→ Fast response time
→ Energy efficiency
→ Color purity

Applications:

→ Lighting
→ Displays

→ Wearable electronics
→ Medical devices
→ Automotive displays
→ Virtual reality and augmented reality.

8C. What are Perovskites materials? Give the properties and applications in optoelectronics devices. 7M

These are 3D ABX, type material where A is an organic cation, ~~B is~~ commonly methyl ammonium cation, X is a halide ion and B is a metal cation.

→ Properties and applications
1) long electron-hole diffusions
2) ultra fast charge transportation
3) high dielectric constant
4) Swift charge recombination
5) longer carrier lifetimes.

All these properties made these materials as the best in thin PV technologies.

Module 5

9a What are concentration cells? The emf of a cell $Ag | AgNO_3(0.02M) // AgNO_3(XM) | Ag$. Found to be 0.084 V at 298 K. Write the cell reactions and calculate the value of X. 6M

The cell is made of two electrodes of same material either the concentration of electrolyte solution varies or the composition of electrode materials varies. Such a cell is called concentration cell.

$Ag | AgNO_3(0.02M) // AgNO_3(XM) | Ag$

$E_{cell} = 0.084\ V$

$T = 298\ K$

At anode $Ag \longrightarrow Ag^+_{(0.02M)} + e^-$

At cathode $Ag^+_{(XM)} + e^- \longrightarrow Ag$ $\quad n = 1$

NCR $\quad Ag^+(XM) \rightleftharpoons Ag^+(0.02M)$

$$E_{cell} = \frac{2.303RT}{nF} \log \frac{C_2}{C_1} \quad \because C_2 > C_1$$

$$E_{cell} = \frac{2.303 \times 8.314 \times 298}{1 \times 96500} \log\left[\frac{xM}{0.02M}\right]$$

$$0.084 = \frac{2.303 \times 8.314 \times 298}{96500} \log\left[\frac{xM}{0.02M}\right]$$

$$= 521.26\ 0.0591 \log \frac{xM}{0.02M}$$

$$1.421 = \log \frac{xM}{0.02M}$$

$$\text{Antilog } 1.421 = \frac{xM}{0.02M}$$

$$26.36 = \frac{xM}{0.02M}$$

$$xM = 0.5M.$$

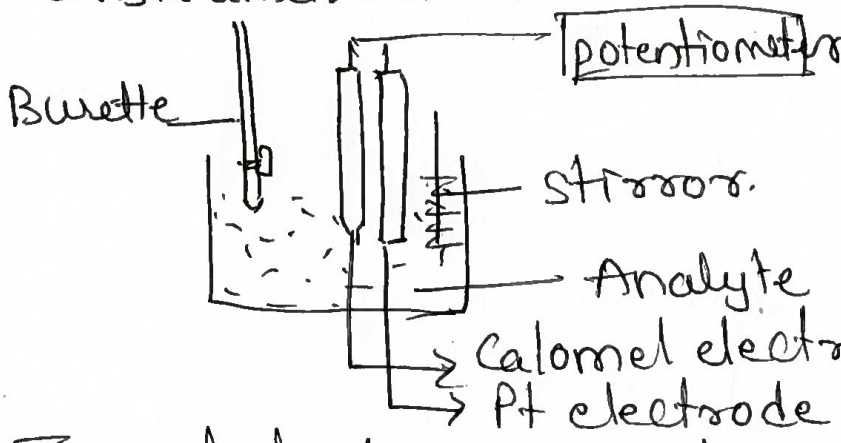
qb Describe the principle, instrumentation, and application of potentiometric sensor for the estimation of iron. 7M

Potentiometere works on Nernst equation

ie. $E_{cell} = E^\circ + \frac{2.303RT}{nF} \log [M^{n+}]$

Potentiometric titration is one in which the end point or equivalence point is determined by measurement of cell potential.

Instrumentation



Two electrodes are used here. Pt and calomel. Pt is responsible for redox type of reaction. Calomel is made of saturated KCl solution. It remains constant during the reaction.

Estimation of iron.

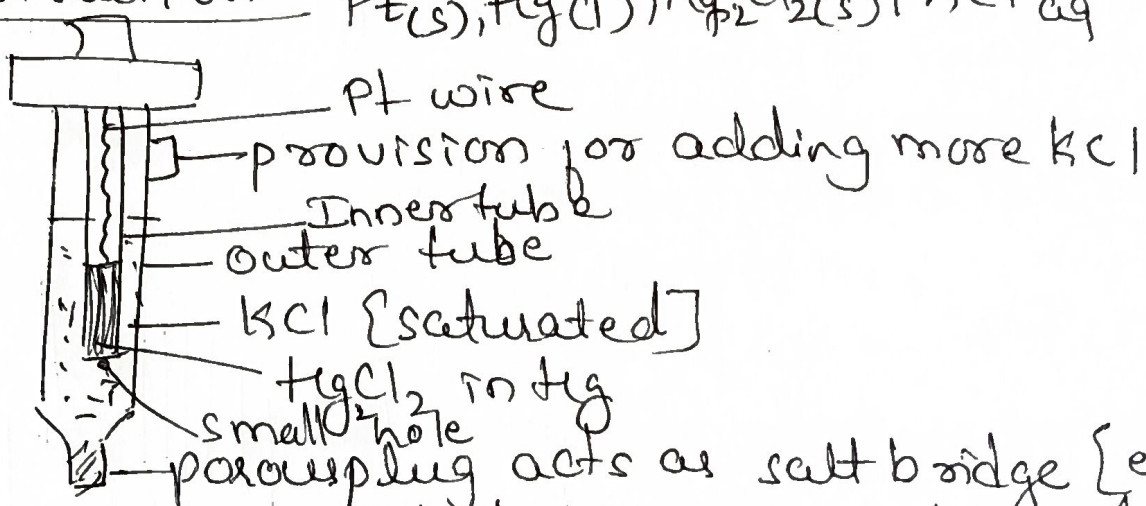
1) The burette is filled with $K_2Cr_2O_7$ soln std one
2) Pipette out x ml of FAS in beaker
3) Add 10ml of H_2SO_4
4) Immerse two electrodes
5) Note down zeroth reading

→ Add 0.5 increments of $K_2Cr_2O_7$
→ Sudden jump at one particular point
→ Take another five to six readings. Calculate ΔE, ΔV, $\frac{\Delta E}{\Delta V}$
→ Plot the graph Y axis $\frac{\Delta E}{\Delta V}$ and x axis vol of $K_2Cr_2O_7$
→ From the graph volume of $K_2Cr_2O_7$ is obtained.
→ Apply $N_1V_1 = N_2V_2$. Calculate concentration of FAS and multiply it with equivalent weight of FAS.

9c What are reference electrodes? Explain the construction and working of calomel electrode. 7M

The electrode whose potential is known used to determine the potential of test electrode is called reference electrode.

Construction — $Pt_{(s)}, Hg_{(l)}, Hg_2Cl_{2(s)} | KCl_{aq}$



Working : $\frac{1}{2} Hg_2Cl_2 + e^- \underset{Ox}{\overset{CR}{\rightleftharpoons}} Hg + Cl^-$

$n = 1$

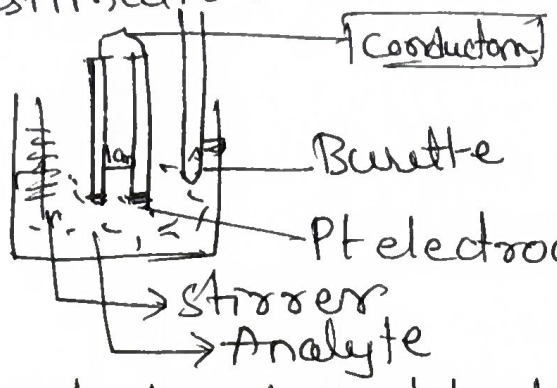
Electrode is reversible to Cl^- ions depends on the concentration of KCl. KCl concentration increases, Electrode potential decreases.

$E = E^\circ - 0.0591 \log [Cl^-]$

used in potentiometric analysis

→ It obeys Nernst equatn to better extent
→ Construction is simple & portable

10a Describe the principle, instrumentation and application of conductometric sensor for the estimation of weak acid.



Conductometric titration is one in which the endpoint is determined by measurement of specific conductivity

→ Conductivity cell is made of two platinum electrodes coated with Pt black and connected through a thole glass loop.

→ Cell is immersed in analyte.

Estimation of weak acid

→ Fill the burette with std NaOH

→ Pipette out 25ml or x ml of weak acid in a beaker

→ Immerse conductivity cell

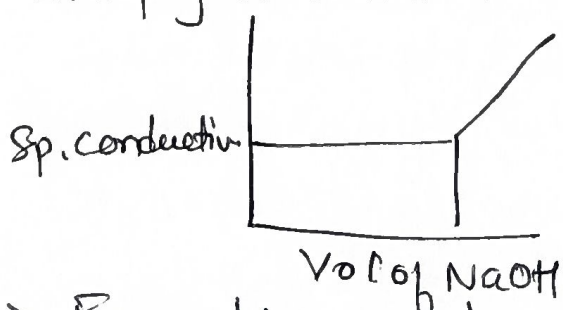
→ Note down Zeroth reading.

→ Add 0.5ml increments of NaOH to beaker containing reaction mixture

→ Plot the graph Y axis specific conductivity & X axis volume of NaOH added in ml

→ $CH_3COO^-H^+ + Na^+OH^- \longrightarrow CH_3COO^-Na^+ + H^+OH^-$

Initially conductivity solely increases because CH_3COO^- and Na^+ both are bulkier in size, They move together slowly. Conductivity solely increases. After neutralization of weak acid the conductivity steeply increases.



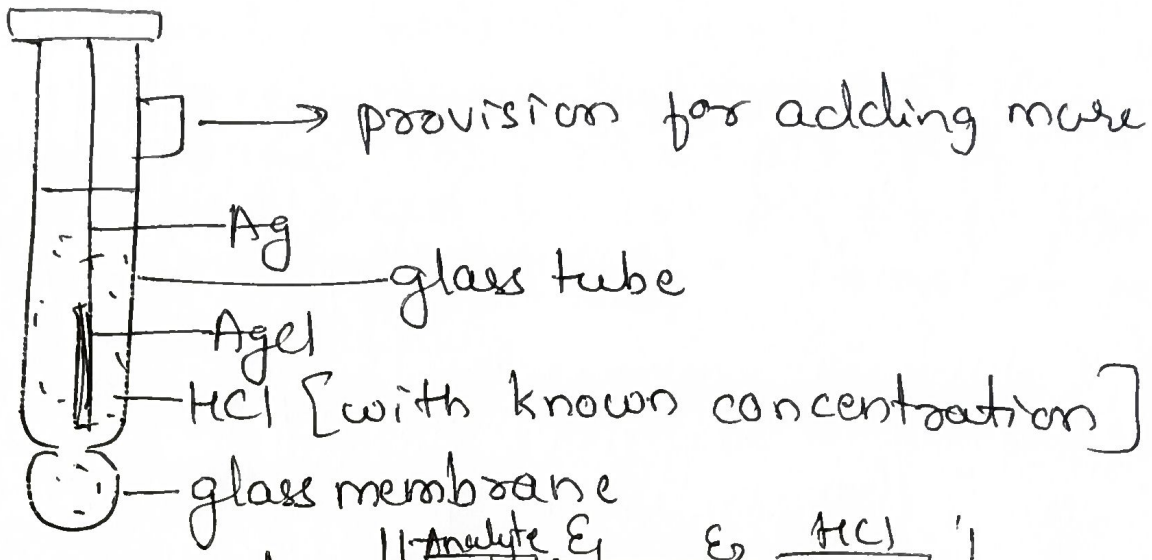
→ From the graph vol. of NaOH obtained.

→ Apply the formula $N_1V_1 = N_2V_2$ Calculate concentration of weak acid

→ Concentration is multiplied with equ of weak acid

10b what are ion selective electrodes? Explain construction and working. 7M

The electrode selects specific ion ignoring other ions.



$Pt_{(s)}; Hg_{(l)} | Hg_2Cl_{2(s)} | KCl \;||\; [H^+]=C_1 \;|\; E_1 \;\; E_2 \;|\; [H^+]=C_2 \;|\; AgCl, Ag_{(s)}$

Analyte (unknown) | HCl (known)

E_{Ref-1} | $E_b = E_1 - E_2$ | E_{Ref-2}

working | glass membrane

$$E_b = E_1 - E_2$$
$$= \frac{RT}{nF} \log \frac{C_1}{C_2}$$
$$= \frac{2.303RT}{nF} \log \frac{C_1}{C_2}$$
$$= 0.0591 \log \frac{C_1}{C_2}$$
$$= 0.0591 \log C_1 - 0.0591 \log C_2$$
$$= -0.0591 \log C_2 + 0.0591 \log C_1$$
$$= L + 0.0591 \log C_1$$
$$= L - 0.0591 (\log C_1)$$
$$= L - 0.0591 (-\log [H^+])$$
$$= L - 0.0591\, pH$$

$$E_1 = E_b + E_{assy} + E_{Ref_2}$$
$$= L - 0.0591\, pH + E_{assy} + E_{Ref_2}$$
$$= L + E_{assy} + E_{Ref_2} - 0.0591\, pH$$
$$= E^\circ_1 - 0.0591\, pH$$

$$E_{Cell} = E_R - E_L$$
$$= E^\circ_1 - E_{Ref_1}$$
$$= E^\circ_1 - 0.0591\, pH - E_{Ref_1}$$

$$0.0591\, pH = E^\circ_1 - E_{Ref_1} - E_{cell}$$

$$pH = \frac{E^\circ_1 - E_{Ref_1} - E_{cell}}{0.0591}$$

$$= \frac{K' - E_{cell}}{0.0591}$$

K' = glass membrane assembly constant.

10C. Explain the principle and working of colorimetric sensor for the estimation of copper. 6M

Principle

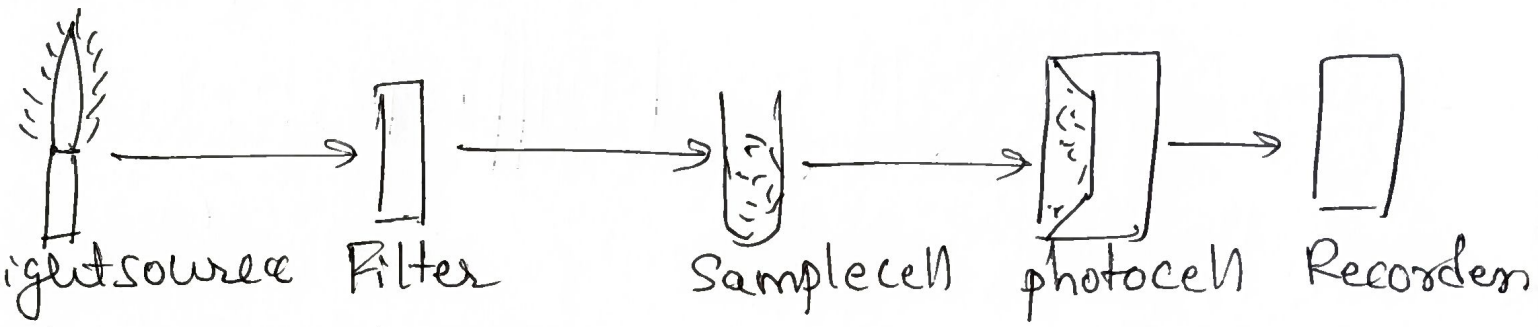
→ Works on Beer lambert's law

When a monochromatic beam of light passes through coloured solution a part of light is absorbed The absorbed light is directly proportional to concentration of soln and thickness of medium

$A = \epsilon C t$

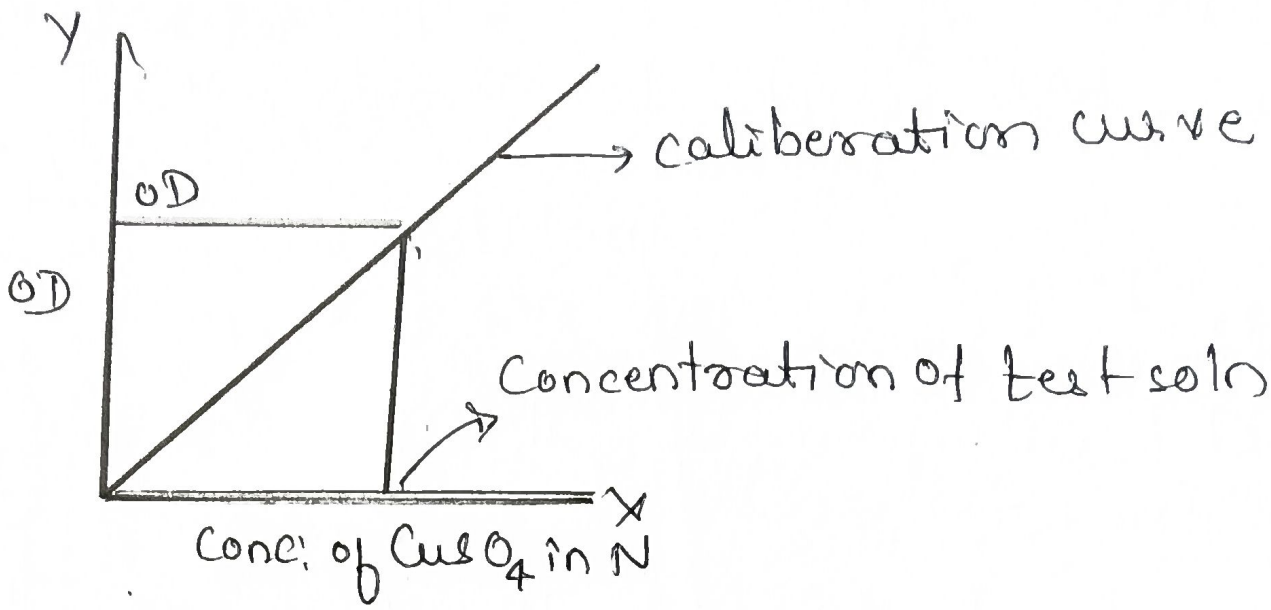
ϵ molar absorptivity constant

Instrumentation



Estimation of copper

→ Take five different 50ml capacity volumetric flask
→ Add 2, 4, 6, 8, 10 ml $CuSO_4$ stock solution to each flask
→ Add 4ml of dilute ammonia to each flask,
→ dilute upto the mark with dist. water.
→ Take another flask add 4ml ammonia & dilute upto the mark with dist. H_2O. called as Blank soln used to adjust OD value Zero.
→ Measure the OD value using Filter 620nm
→ A caliberation curve is obtained by plotting Y axis OD & X axis Conc of $CuSO_4$
→ Now test soln OD is measured and compared on caliberation curve
→ The concentration of unknown is obtained It is multiplied with eq wt of Cu to get the amount of copper present in test solution.
→ In this way the colorimetric sensor used for the estimation of copper.



Staff incharge
Dr. Snehalk

07/7/2025
HOD, BSH
Dr SM Galagali

(Dr. G Hatti)